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ABSTRACT

This paper describes the use of distance learning capabilities to augment and amplify the learning opportunities for part-time graduate students at George Mason University. The students in the biochemistry course described meet periodically on campus for brief interactions with the instructor and peer classmates. Between these synchronous interactions, the class World Wide Web site supports: (1) ongoing asynchronous small group interactions with the professor, peer groups, and other scientists through online discussion groups, e-mail, and listserv facilities; (2) hypermedia presentations on key concepts, developed for and often by the class, and available online for review or correlation to lecture notes; and (3) imaging and audio interactions offering advanced representations of molecular structures, using tools that provide a dynamic and easily updated capability beyond material available in the text. Topics discussed include: the rapidly growing importance of biochemical knowledge; the course objective; the course background, including the nature of the students served, instructional advantages of the Internet format, and the metabolism visualization component of the course; and user viewing tools, including molecular imaging software (RasMol, Chime, MAGE) and database browsing and querying software. Two figures illustrate the class home page and Chime Image views of the tryptophan amino acid molecule. Contains 11 references. (Author/DLS)

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A Pilot Project in Augmentative Distance Learning...
George Mason University Graduate Course in Biochemistry

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Abstract: Distance Learning programs tend to be thought of as alternatives or replacements for traditional classroom or laboratory-based instruction. We are exploring a third use of distance learning capabilities-- to augment and amplify the learning opportunities for part-time graduate students. Many graduate students in George Mason's programs converge on one of the campuses for brief periodic interactions with the instructor and peer classmates. Between these synchronous interactions, the class Web site supports:

- ongoing asynchronous small group interactions with the professor, peer groups, and other scientists through online discussion groups, email and listserv facilities;
- hypermedia presentations on key concepts, developed for (and often by) the class, and available online for review or correlation to lecture notes;
- imaging and audio interactions offering advanced representations of molecular structures, using tools that provide a dynamic and easily updated capability beyond material available in the text.

Introduction

Students of modern biochemistry today find themselves in what is at once a very exciting and a very challenging situation. Our knowledge of biochemical systems is increasing exponentially, as the research tools applied in this area become more powerful and more laboratories address biochemical questions in an increasing number of areas. An important driving force for this rapid expansion of knowledge is the advent of an expanding biotechnology industry, in which detailed knowledge of biochemical processes allows the practical application of this information in ways literally unimagined only a few years ago. That's the good news. The bad news is that students often find themselves overwhelmed with the volume of information with which they are confronted, and are often at a loss when trying to make sense of it all.

Objective

To provide students a means of visualizing the molecular aspects of Life's chemistries while pursuing and acquiring an intuitive understanding of the complex, interactive dynamic systems, upon which all life forms are based.

Background

Biotechnology, as an industry, requires a work force well trained in the cellular and molecular biosciences. Individuals seeking professional careers in the biosciences, need to understand the molecular basis of their science and the tools employed in its pursuit. The impact of knowledge arising from completion of the "Human Genome

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Project" in a wide array of academic and commercial applications will increases the need for individuals t o understand the "Chemistry of Life." A fundamental understanding of Science is now a critical element in th e education of all members of our Society. Advances in the molecular and cellular biosciences have and wil l produce knowledge, the use of which, will impact individuals in all walks of life. A means of capturing an d presenting concepts from the molecular biosciences in a manner useful t o students at various levels of preparedness is essential. As course work in Biochemistry is expected to provide the basis for an understanding of life at the molecular level, it serves as an ideal setting for developing enhancements to student acquisition of these concepts. We are employ ing multimedia approaches in our one year graduate course in Biochemistry at George Maso n University, with the end product sought being a fully web-based course. A major theme of the course is th e relationship between molecular structure and biological function.

The Internet allows students to access biochemistry information soon after it is made available to the scientific public. This rapid access to new knowledge is unprecedented, and is rapidly changing the way biotechnologists do their work every day. The students receive training in ways to use tools and methods that will allow them to access and analyze this informatio n in an efficient and effective manner. An essential feature of this course is the use of World Wide Web Browsers coupled to Molecular Modeling and Display software on assignments designed to illustrate practical problems and tasks that arise in applied biotechnology. Information describing thes e relationships were once located only in books and journals located in research libraries. Today much of thi s information resides on host computers connected to the Internet. Students use Web Browsers connected t o Molecular Modeling and Display software to locate and analyze molecular structures of important biochemical systems currently under investigation wor ld wide. This permits us to design a system that provides "just-in-time", "just-in-case" and "just-for-you" solutions for the students.

While the fundamentals underlying any textual presentation in Biochemistry are relatively stable, advances in knowledge and technologies associated with this field are remarkably rapid. Establishing pointers to ongoin g research through our web based instructional platform, allows students to fully appreciate this dynamic. It also serves to tie the materials learned in the class s etting to real world activities of the moment. The capacity to "see" molecules in a variety of representations, enhances students' abilities to comprehend "structure/function " relationships, especially for t he higher order macromolecular assemblages encountered in discussions of Proteins and Nucleic acids and their roles in biological systems.

Nature of the Students Served:

The class composition is made up largely of part time graduate students who are employed full time. Thes e students are mature, and come to the course from a variety of disci plines. Graduate students from the Departments of Biology and Chemistry, and the Computational Sciences and Informatics Institute utilize this course as part of their formal course requirements. Thus, backgrounds are not uniform. This lack of uniformity is addressed throug h the web site by incorporating pointers to information resources that can both remediate and amplify a student's knowledge in a particula r subject domain. Thus students with weak background in chemistry are given pointers to sites of information a ppropriate to their needs, while students seeking additional information or depth in a topic are pointed to sites of information that meet this opp ortunity. Given the enhanced role of Bioinformatics in modern biology and biochemistry, additional instruction in the applications of computer-based search, retrieval and computational tools are incorpora ted as well. This also provides a means of instruction through "doing" that increases the opportunities for students to explore structure fu nction relationships across a wide range of biological and biochemical processes and highlights at the molecular level the conc ept of "Unity in Diversity" so fundamental to all of Life's forms.

Instructional Advantage:

The course Web site (http://www.america-tomorrow.com/gmu/biochem) is maintained on a commercial server that is available 24 hours a day, 365 days a year. The Web site contains objectives and syllabus for the course , presentations used to augment the text, and s tudent-provided pages dealing with current event topics dealing with

Figure 1: Class Web Site Home Page

Biochemistry, Molecular Biology, and Molecular Genetics. These pages contain links to news items, plus links to background information on research sites dealing with the news topic. For example, news reports on the Pfisteria attacks on fish in the Chesapeake tributaries are linked to the N.C. State University Research reports that identified Pfisteria Piscicida and its unique capabilities to transform into 24 flagellated, amoeboid, and encysted stages or forms. (http://www2.ncsu.edu/unity/lockers/project/aquatic_botany/pfiest.html)

Use of the Internet in class for example, allows capture of detailed, high level information on a subject in response to a question, in a fashion impossible via other means. One can also, move to sites of information appropriate to remediation of background preparation on site and in real time as well. In all cases, having the capacity to present, especially the molecular concepts, in a manner that is easily perceived is a marked learning enhancement for the students. Now, one can see, in color, a molecular representation, that before these technological advances, required of students, a capacity to mentally construct their own "abstract 3D" representations... a skill not shared by many.

Asynchronous communication among groups of students and the instructor is supported with a "List Serve" and extensive use of e-mail for one on one communication, and a class discussion forum implemented on the George Mason University "Town Hall" bulletin board system (an application of the Lundeen Corporation "Web Crossing" software). Group student projects are facilitated by the use of private Chat rooms that allow synchronous communication. Given that most students do not reside on campus and work schedules do not permit extensive face-to-face time, the Chat sessions permit the students to "get together" at any time to discuss project direction and status. We have used private rooms in the Talk/Excite public facilitiy as well as the more limited Chat capability of the University server. Capturing Chat sessions provides a built in documentation that is helpful to the instructional staff in following the development of the project. This facilitates tailoring of instruction, discussion and information retrieval and presentation to individual student's needs.

Student projects are greatly improved through this approach, both due enhanced input and interaction between the student and the instructor during the project's design, and also in terms of the multiple avenues now open to

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the student for the project's presentation. Every effort is made to move the students toward use of a web based presentation. The electronic linkage of students allows collaborative projects among students whose free time is extremely limited and thus would otherwise be unable to perform projects in a team fashion.

The students also have the opportunity to develop mentor-mentee relationships with more experienced peers, full-time and adjunct professional staff, and expert guests who appear in the departmental seminar series.

Visualizing Metabolism:

One objective of the full year course is the acquisition on the part of the students of an "intuitive" understanding of life processes at the molecular level. In effect, a "visualization" on the part of the student of metabolic processes both structural and informational. The multiplex of information and the hierarchy of linkages between information sets that comprise metabolism in all its forms is now accessible in a fashion that provides a marked enhancement to student learning. Database coupling and linkage produced as a result of the Human Genome Project, allows pursuit of integrative concepts in Biochemistry in a fashion never before possible. The course seeks to utilize these databases and the computational tools generated for their perusal in aiding the student's acquisition of an intuitive grasp of the molecular dynamics of cellular function. It is here that hypermedia presentations become most useful and appropriate. This aspect of the course also provides the greatest opportunity for "learning by doing." It also lends itself to team approaches to projects involving complex higher level biological functions and attempts at understanding these phenomena at the molecular level.

The course has been designed to introduce students to the basic fundamentals of biochemistry. Emphasis is placed upon topics and approaches that are of most practical use to students working in various areas of biotechnology. A major recurring theme of the course is the relationship between molecular structure and biological function. Many important examples of these relationships are given in the textbook for this course. Much more current information exists within databases and other files on host computers all over the world. The advent of the Internet allows biochemistry students to access this information soon after it is made available to the scientific public. This rapid access to new knowledge is unprecedented, and is rapidly changing the way biotechnologists do their work every day. The students receive training in ways to use tools and methods that will allow them to access and analyze this information in an efficient and effective manner. An essential feature of this course is the use of World Wide Web Browsers coupled to Molecular Modeling and Display software on assignments designed to illustrate practical problems and tasks that arise in applied biotechnology.

Information describing these relationships were once located only in books and journals located in research libraries. Today much of this information resides on host computers connected to the Internet. Students use WWW Browsers connected to Molecular Modeling and Display software to locate and analyze molecular structures of important biochemical systems currently under investigation world wide.

Using viewing Tools

Software tools are available to allow biotechnologists to examine details of biomolecular structures. Some of these are commercial products that require very powerful graphics computer workstations. The current versions of Mac and PC computers however have sufficiently powerful hardware and operating systems so that public domain or shareware programs can provide every student with tools quite adequate for learning the important fundamentals of biomolecular structure. Several of these will be provided for students in this course. These include:

Molecular Imaging Software:

- **RasMol** a program for viewing structures whose coordinates have been presented in "PDB" format. Structures may be viewed at various levels of detail and abstraction.
- Chemscape **Chime** a "plugin" for Netscape and other Web browsers that allow you to view and manipulate Protein Data Bank and other molecular models directly from a Web page.

- **MAGE**, a program for viewing images and playing Kinemage Script files. This program and the script language which direct it was developed by David Richardson at Duke University. The journal Protein Science makes extensive use of this image analysis software.

Figure 2: Chime Image Views of the Tryptophan Amino Acid Molecule

Database Browsing and Querying Software:

- 3DB Browser, a program for convenient selection of Protein and Nucleic Acid structures deposited in the Protein Data Bank
- Klotho is a useful Biochemical Compounds Declarative Database.
- The European Bioinformatics Institute is a source of both nucleotide and protein (SWISS-PROT a protein sequence database) Databases and related software .

Summary

Multimedia technologies allow compilation and presentation of subject matters in biochemistry in a highly flexible and rapid fashion. This provides the instructor with a ready means of capturing both new and remedial materials on an as-needed or available basis. In combination, these capabilities provide a means of tailoring instruction to the individual needs of class members. It also provides a mechanism for capture and distribution of knowledge and insights of the class participants.

Given the importance of computer-based technologies in all aspects of modern biosciences, both theoretical and applied, a knowledge of these tools and the value of their application becomes basic to a student's education in the cellular and molecular biosciences. Bioinformatics is now an integral element within these areas of study. Our course design and its formulation and presentation as a Web site is intended to both take advantage of and force the students use of, the concepts and tools associated with this evolving discipline.

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